

Multifunctional 2D- Materials: Selenides and Halides

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Material is the key component and controls the performance of the detectors, devices and sensors. The materials design, processing, growth and fabrication of bulk and nanocrystals and fabrication into devices and sensors involve multidisciplinary team of experts. This places a large burden on the cost of the novel materials development. Due to this reason there is a big thrust for the prediction of multifunctionality of materials before design and development. Up to some extent design can achieve certain properties. In multinary materials processing is also a big factor. In this presentation, examples of two classes of industrially important materials will be described.

There is a great need of materials for frequency conversion (nonlinear optical NLO) and imaging materials that can be used in the visible, near-infrared wavelength, mid wave infrared (MWIR), longwave wave infrared (LWIR) and even up to Tera hertz wavelength (THW) regions. However, among several factors, availability of a single material to meet requirement of transparency, NLO coefficient, low absorption coefficient and power handling capability are major parameters. Most of the oxides, including lithium niobate, suffer due to its high absorption coefficient at above 4 μm . For high power laser optical parametric oscillation (OPO) applications, extremely low absorption is required at the pump and signal wavelengths. A similar criterion applies for second, third and higher order harmonic generation from CO_2 lasers for 9-10 μm wavelength region. In spite of more than four decades of investments and promises on variety of phosphides and arsenides, there is no single multifunctional material which can meet these challenges. To overcome these problems, we have designed and investigated halides and selenide classes of materials [1-2] with unusual properties. These materials are anisotropic and in many cases involve covalent and Van der Waal forces making processing very difficult. We will describe recent work of highly anisotropic gallium selenides, thallium gallium selenides, mercurous halides and ternary thallium mercury halides for imagers and frequency conversion. Some relevant experimentally determined properties in THz will be also presented. Results on these materials indicate that these have very low absorption coefficient in their transparency region. Among this class of materials GaSe has strong tendency of cleaving due to Van der Waal forces along $-C$ direction making 2D materials possible. The ternary and quaternary materials have a large flexibility to design transparency, damage threshold and effective performance. Because of the problems thallium based ternary compounds Tl_3AsSe_3 and quaternary compounds $\text{AgGaGe}_3\text{Se}_8$ and $\text{AgGaGe}_5\text{Se}_{12}$ were also designed and grown. These crystals do not require annealing, show very large transparency range and have extremely low absorption coefficients. In addition to the bulk crystal growth we have made significant progress in developing quasi-phase-matched structures for frequency conversion. A brief summary on nano, micro and bulk morphologies and its effect on performance of these materials will be presented.

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References:

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